TIME AS CHRONOS AND KAIROS
Physical and metaphysical time

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1. Introduction

Chronos is the time of physics and kairos is an ordered but unmeasured kind of time outside space-time. Kairos is fundamental, and chronos is derivative. In spite of their origin in Greek, chronos and kairos are used in this paper as technical terms in English. Simpler forms are ‘physical time’ for chronos and ‘metaphysical time’ for kairos.

Models for happening, or becoming, are discussed after applying General Relativity to the tree of possible worlds and postulating a definition of the present which sidesteps the relativity of simultaneity. The resulting two kinds of time, chronos in space-time and kairos outside it, provide a smooth bridge from physics to metaphysics and the philosophy of religion.

Earlier PIRT Conference papers [1, 2, 3] developed the basic idea and led to a published paper [4]. A different Conference paper [5] began to investigate the metaphysical and religious aspects. A new development in this paper is the use of a particular mathematical structure for kairos, different from that of the real numbers.

2. Relativistic present

It is a feature of relativistic space-time that it carries no indication of what is happening ‘now’. In general, space-time shows the positions of all particles at all times. It therefore has the character of a graph of space against time, albeit a very elaborate one. In order to have a closer relationship with physical reality, many thinkers would like to see space-time with a succession of ‘nows’, not only on each world-line but in the form of a family of objective, universal presents, each of which partition space-time into two regions (‘past and ‘future’); where a ‘present’ is the set of events happening at some ‘now’. This would constitute an description of ‘becoming’

There is a commonsense assumption that the present, if it exists, contains only simultaneous events. The psychological pressure exerted by this assumption has led many scholars to abandon the search for a universal, objective present, because Einstein proved simultaneity to be relative to the observer, and repudiated an objective present. Dr. John Varriano [6] reports a quotation from:

> *Albert Einstein, in a letter written on March 21, 1955 to the children of his friend, Michele Besso, who had just died. (Einstein was ill at the time and knew the illness would most likely be his last.)*
>
> *"And now he has preceded me briefly in bidding farewell to this strange world. This signifies nothing. For us believing physicists, the distinction between past, present, and future is only an illusion, even if a stubborn one."*

In spite of all this, it is still logically possible to make a different deduction from the relativity of simultaneity, provided only that the connection between the present and simultaneity is severed. Then the deduction is simply that the present is not given by simultaneity. This is not possible in Newtonian mechanics, but it is possible in relativity.

The necessary condition that two present events cannot influence each other, is satisfied if the present is postulated to be a spacelike hypersurface in space-time.

In the Newtonian limit of special relativity, the spacelike hyperplanes through a given event ($\mathbf{r}_1$, t_1) fall together and coincide with the present $t = t_1$, which equation also specifies space. This disguises the fact these things had different origins in special relativity. Einstein was thinking of what is dealt with in the basic theory of relativity, and no doubt assuming a present would need simultaneity, whereas the present can be postulated as an application of the theory. Although the situation is not quite the same, one may also say that the basic theory does not give thermodynamics, statistical mechanics or hydromechanics, but that these are treated as applications [7].

In spite of giving up the concept of the present in special relativity, it has often been noted [8] that in cosmology with the metric $ds^2 = c^2 dt^2 - dl^2$, where dl^2 is some spatial metric, the variable t provides a universal cosmic time, under which t = const is the present. This present naturally has the form of a spacelike hypersurface. However, using special relativity in a local inertial frame with cosmic time t as time coordinate, the connection between the cosmic present and simultaneity is lost as soon as a Lorentz transformation is made to some other local frame. This is therefore a particular case of the general hypothesis that the present is some objective spacelike hypersurface.

The present author did not originate this idea. It was explicitly proposed by Nicholas Maxwell in 1985 [9], but not developed then. Subjective experience of the present was treated fictionally on the same basis by Fred Hoyle and Geoffrey Hoyle as early as 1963 [10], although it works equally well for an objective present.

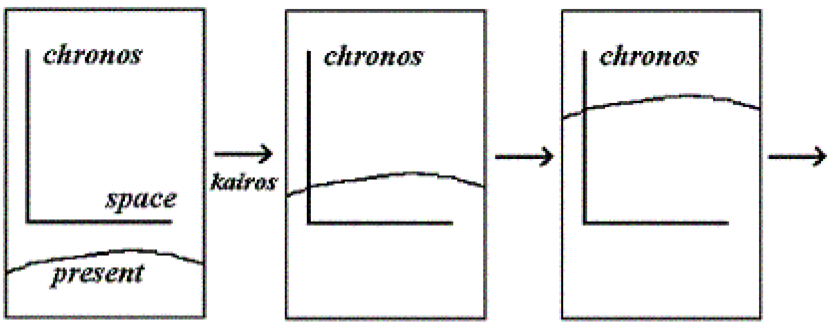

Figure 1. Chronos and kairos

The changing ‘now’ calls for a family of presents covering the whole of space-time. The author has developed this hypothesis in spite of not being able to give a general prescription of precisely where the present might be. Since space-times vary as the designated present varies, the sequence of space-times with continuously varying presents provide a temporal sequence which is outside of space-time. This aspect of time is termed *kairos*, and the time of clocks and time coordinates is termed *chronos*. ‘Space-time’ is in fact space-chronos, but the usual name is unambiguous.

To avoid confusion, temporal relations are restricted to the following terms or their derivatives:

Table 1. Temporal terminology

Type of time	Relation	Other terminology
Chronos, Physical time	**earlier–later**	Simultaneous, chronological
Kairos as seen in space-time, Tense	**past–future**	present, copresent events, now
Kairos outside space-time, Metaphysical time	**before–after**	present, now, kairological

Tree of possible worlds
An open future is allowed for by postulating an abstract tree of possible space-times, agreeing up to the present and then branching in the future. They branch at a present [4]. Possible space-times are modelled using General relativity. The state of affairs in any present is here termed a *world*.

3. Programs for becoming

Change of present, colloquially called 'the flow of time', is modelled by a program like a computer program running in the 'realm of kairos', or kairos outside space-time. Chronos is modelled as usual, by a continuous real variable.

A model for kairos may be built up from various requirements, some of which merely commend themselves as the best option. To be a kind of time, kairos must have order, and in some situations partial order may turn out to be desirable. It seems reasonable to require that the elements be densely ordered and complete under this ordering (see below, Postulate 5). The idea that kairos should produce no "pressure of time" is one reason for taking kairos to have no measure. Program 2.00 below show the advantage of the elements of kairos having cardinality greater than that of the real numbers. The cardinality might possibly be so high that the elements of kairos only form a class, not a set. Consequently the following postulates are proposed for the abstract mathematical structure of kairos:

Postulate 1. Kairos **K** is a class of elements of cardinality greater than that of the continuum.
Postulate 2. Reference may be made to any element of **K**.
Postulate 3. **K** is ordered linearly or partially by <, 'lower than'. (The order > will be called 'higher than'.)

The notation for intervals will follow the pattern $[a, b) \equiv \{x \mid a \leq x < b\}$.

Postulate 4. Denseness. If $a, b \in \mathbf{K}$ then there exists $c \in \mathbf{K}$ such that $a < c < b$.

Definition 1. For $m \in \mathbf{K}$, if $m \leq$ all elements of a subclass S of **K**, then m is a Lower Bound [LB] of S, and if m is the highest element with this property, it is the H[ighest]LB of S. Similarly for H[igher]B and L[owest]HB.

Postulate 5. Completeness. **K** is complete under its ordering, in the sense that all HLBs and LHBs are elements of **K** (excluding the lowest and highest elements if they do not exist). (Postulate 5 makes a kairos variable continuous.)
Postulate 6. Every interval in **K** has the same cardinality.
Postulate 7. No metric is defined on **K**.
Postulate 8. Any subinterval of **K** may be partitioned into continuum many subintervals, none of which is a singleton. (The point of Postulate 8 appears in Theorem 1 below.)

In the models considered here, agents in chronos or kairos, i.e. in space-time or in the realm of kairos, are given the opportunity of 'suggesting' the course of the future. Because this may lead to clashes, an agent at the highest level, the 'highest agent', is recongised, who has the last word. The following assumptions are made for the practical application of the mathematical structure of kairos:

Assumption 1. The highest agent may perform any infinite number of tasks.
Assumption 2. Any interval in **K**, except one bounded above by the highest element, may be traversed. (Assumption 2 blocks the analogues of Zeno's paradoxes of motion.)
Assumption 3. **K** has no lowest or highest element. (These may also be referred to as a first or last element.)
Assumption 4. Even if **K** is metricizable, no metric is recognised in practice.

Program 1.00 is the basic program for becoming (simplified from earlier publications), under which worlds change through a small interval of chronos along a 'thread' or continuous timelike line through the presents. The letters u, v, w denote worlds, and u_0 is not a world but a limit corresponding to a singularity. The meaning of 'v_A is close to u' is that the corresponding presents are close in chronos. The program is shown here in schematic form:

Program 1.00

10. Initialize u as $u = u_0$.
20. For each agent A in chronos, or in kairos except the highest agent, input a future world v_A desired by A, where $u < v_A$ and v_A is close to u.
30. The highest agent inputs v, where u < v and v is close to u.
40. The actual world, w, changes such that $u < w \leq v$.
50. Put u = v.
60. Go to 20.

Discussion of Program 1.00
Program 1.00 allows only for primary causes. Thus the program envisages input from conscious agents at each stage and a final decision by the highest agent. Change of kairos may therefore be attributed to personality, or ultimately, to life. Secondary causes are included in Programs 1.01, 2.01 below.

Statement 10 corresponds to the creation moment of the physical world. If the universe is beginningless in chronos (see below, Figure 5), there is no initial statement.

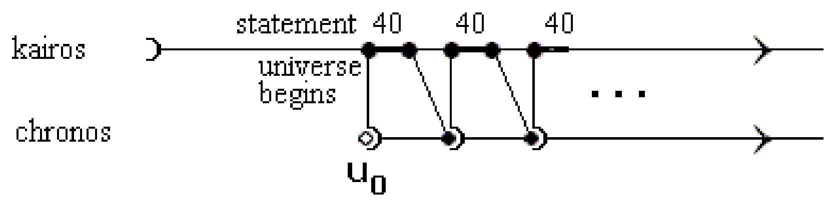

Figure 1. Program 1.00

Statement 20 then calls for suggestions for a world v on a particular branch of the tree of possible worlds. This will determine the intermediate worlds in (u, v]. At Statement 30 the highest agent makes the final decision., which is implemented at Statement 40. The corresponding changes of present induce a continuous change of chronos. Since any time variable which has the nature of chronos is an independent variable in the physical world, there is no such thing as the rate of change of chronos itself. The implementation of Statement 40 may take any interval of kairos.

After this, Statements 50, 60 restart the loop while keeping w=v, i.e. the actual world remains constant in kairos until the next implementation of Statement 40.

Circular explanation, or infinite regress?
The model does not make use of an infinite regress of 'times' in its attempt to explain the flow of time. Does it, however, give a circular explanation by attributing changes in chronos to changes in kairos? This must be strenuously avoided if the model is to be of any use philosophically.

It was therefore postulated [4] that agents in kairos make kairos change along their individual kairos-lines ("time-lines"), simply by being live agents. This gave rise to a partially ordered structure. However, the program may be postulated to run on the linearly ordered kairos-line of the highest agent, with elements **K**.

It was also originally thought [4] that the partially ordered structure of kairos would not exist beyond the present of each agent in kairos. The alternative is to consider that kairos variables along each of these lines exist *in the abstract* without higher limit.

Program 2.00
Theorem 1. (*Embedding*.) If S is any subinterval of **K** of the form [a, b], it is possible to select a discrete subset R = {a, c, ..., b} of S with continuum many elements.

Proof. By Postulate 8, the subinterval S may be partitioned into continuum many subintervals [a, c], (c, d], ..., (z, b]; and [a, c] is not a singleton. Take R = {a, c, d, ... , z, b}. R is discrete because $a < c < d < ... < z < b$.

Note that S may be **K** itself. Many other sets R may be formed on the basis of density. The theorem may obviously be adapted to other types of subinterval S.

Corollory 1. If S is any subinterval of **K**, it is possible to select a discrete subset of S with $\aleph_0$ elements. (Take a countable subset of R.)

A variation of the program is now obtained using Theorem 1. At Statement 30 an interval (u, v] of worlds, having continuum many elements, is chosen for direction in which the program will go. In this variation it is possible for each loop to take actual world as the 'next' world, where:

Definition 2. n(u) is next to u iff n(u) > u and there is no world p such that n(u) > p > u.

Now let Statement 30 finish at kairos a, with the actual world being u. For any b>a, the kairos interval S = [a, b] contains a discrete subset R ={a, c, ...}, where a < c < ..., with continuum many elements (Theorem 1). With world v chosen as before, map [u, v] onto R by $u \to a$, $n(u) \to c$, etc. Then the program will call for the actual world to become n(u) at kairos c. The arrangement is:

$$S = [a, b] \supset R = \{a, c, \dots , b\} \supset \{a, c\} \leftrightarrow \{u, n(u)\}.$$

Then the program is:

Program 2.00

10. Put u = u_0.
20. For each agent A in chronos, or in kairos except the highest agent, input a desired world v_A, where $u < v_A$ and v_A is close to u.
30. The highest agent inputs v.
40. Put the actual world w = n(u) for the selected branch (u, v].
50. Put u = n(u).
60. Go to 20.

This corresponds to Figure 2. Note that in Program 2.00 the world v may change each time the loop is executed, and only the first two elements of R are needed.

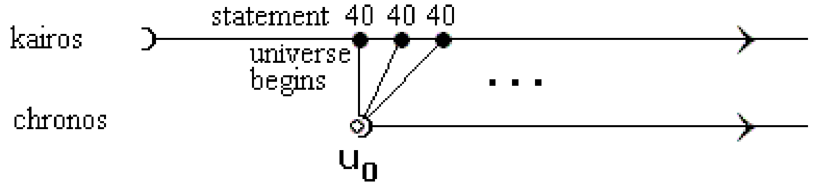

Figure 2. Program 2.00

Secondary causes
To include secondary causes, which may be formally attributed to laws of nature, one more statement is needed:

Programs 1.01 and *2.01* *Insert:*

25. Input the effects of the relevant laws of nature.

If there were only one possible space-time it might be conceivable for a changing kairos to be an ultimate feature of things, and events to follow solely from a set of laws. With an open future, modelled by many possible space-times, there has to be choice. Hence Statement 20 is still included.

4. Age of the universe

Figure 3 shows a universe with infinite chronological age under Programs 1.0x. Figure 3 is analogous to a diagram in projective geometry showing two parallel lines meeting in the line at infinity. The actuality cannot be understood by the finite mind. It is clear, however, that if the amount of chronos along the thread at each step has finite bounds, then from u_0 up to now the total chronos is infinite.

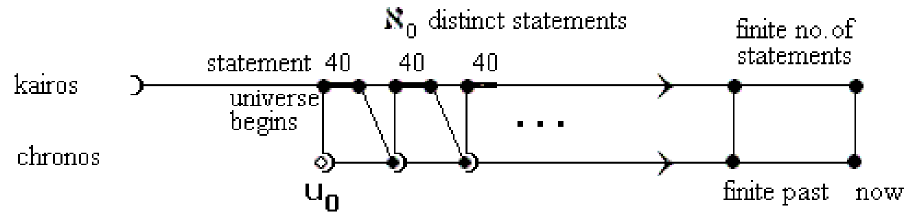

Figure 3. Infinite age under Programs 1.0x

This challenges the traditional argument against infinite age – that an infinite ‘time’, i.e. chronos, cannot be passed through. The argument is then confirmed by saying, ‘Try to go backwards through infinite ‘time’ (chronos)’, a process which does not terminate. In Programs 1.0x we do not have the difficult task of working through infinite chronos, but instead the infinite task is performed in kairos by the highest agent. This is covered by Assumptions 1 and 2.

For Programs 2.0x, Figure 4 envisions a particular set of continuum many statements which are mapped 1-to-1 to the interval (u_0, now] of infinite length (instead of finite length as in Figure 2).

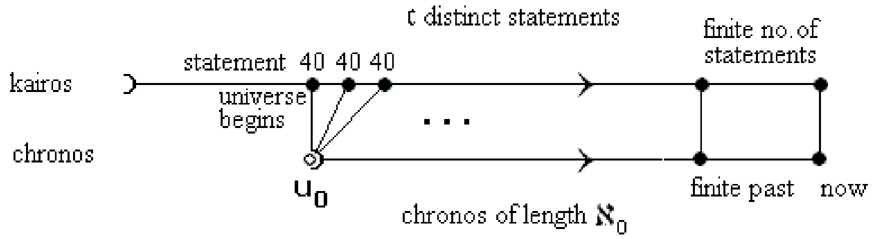

Figure 4. Infinite age under Programs 2.0x

Beginningless universe?

Instead of distinguishing between finite or infinite age in chronos, with the lurking possibility of a logarithmic (or other) transformation between a chronos of $-\infty$ and a chronos of 0, it might be clearer to distinguish between universes which have a beginning and those which do not.

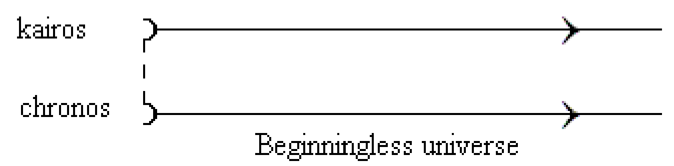

Figure 5. Beginningless universe

In Figure 3, even though an infinite number of steps have been taken up to the present, the universe has a beginning at a particular element of kairos. In fact in each of Figures 1-4 the universe has a definite beginning.

In Figure 5, the universe is beginningless. The open lower bound of kairos with endless lower and lower elements is paralleled by the open lower bound of chronos with continuum many values less than any value however near the lower limit. The universe here has no beginning in kairos, and this is a clearer condition for beginninglessness than an infinite value for the 'age of the universe'.

5. Benefits of recognising a present

Both physicists and various sorts of philosophers have struggled with different relativistic frames when an objective present would simplify the situation considerably. Examples include the collapse of the wave function [4, 11], Storrs McCall's model of the universe [12], tense logic [13, 14], and current discussions of God in the philosophy of religion [15, 16].

Terminology

One of the benefits is the possibility of more precise language about time. For instance, when Augustine of Hippo wrote that 'God created the world with time, not in time', his thought may be restated as 'God created the world with chronos, not in chronos'; but it is also possible to hold the more refined view that 'God created the world with chronos and in kairos'. Another such phrase is 'before creation' [17], which agrees with the current proposals (Table 1).

Divine action in the world

When John Polkinghorne [18] writes that,

> *The God who interacts with the history of the universe must be a dipolar God, possessing a temporal pole as well as an eternal pole,*

the phrase 'temporal pole' may be understood as 'kairological pole'. Discussion of the Programs sketched above, and further variations of them, is relevant to the 'Divine Action Project' [19], in which the participants are seeking how to understand God's action in the world (as are other scholars).

6. Conclusion

In spite of widespread misunderstanding, it is possible for there to be an objective, universal present in relativity, as a spacelike hypersurface. Then the varying present corresponds to a linear sequence in kairos outside space-time. The essence of the theory is:

(1) the present does not require simultaneity, but is a spacelike hypersurface in space-time;
(2) the family of presents within space-time is linearly ordered in kairos;
(3) kairos changes by the action of the highest agent (i.e. God, in a theistic context).

Programs for becoming with certain postulates and assumptions for kairo provide specific models for focussed discussion with a view to improvement. Many details of kairos and its 'realm' remain for further expoloration.

Possible infinite age of the universe is contrasted with its possible beginninglessness.

The models presented here are not expected to contain the final answer to the problem of time. In any case, the theory is not meant to depend on the correctness of General Relativity, or the particular forms mooted here for the program for becoming. For instance, the programs may be fine tuned to take account of particular theories of divine action.

Finally, could it be that kairos is of extremely large cardinality, even unimaginably large? And might a better description of the physical world be obtained by using something larger than the real numbers?

APPENDIX

A theorem on LHBs and HLBs

The following basic theorem and its proof are adapted from real analysis [20].

Theorem 2. If m is the HLB of a subclass S of **K**, then (i) $m \leq$ any element of S, (ii) if $m<n$ then $n >$ some one element of S. Analogously for LHB.

Proof. (i) Suppose $s<m$, ($s \in S$). Then there exists $p \in S$ such that $\mathbf{s < p < m}$. Now $p<m$ means p is a LB, but $s < p$ contradicts that.
(ii) Given $m<n$, there exists $q \in S$ such that $\mathbf{m < q < n}$ by density. Suppose $\mathbf{n \leq x}$ for all x in S. Then $q < x$ so q is a LB, but m is the HLB and $m < q$ contradicts this.

Similarly for LHB.

Note that in real analysis the point of (ii) is that n-m may be as small as desired. Analogously, n in **K** is any element $>m$.

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